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Biogeosciences Discussions

Interactive comment on "Emission of monoterpenes from European beech (*Fagus sylvatica* L.) as a function of light and temperature" *by* T. Dindorf et al.

T. Dindorf et al.

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Author's response to anonymous referee 2:

We are grateful for the referee's comments. Overall the referee was extraordinary concerned about the representativeness of our measurements as well as our experimental setup in general. However, we strongly disagree with the referee's comments and we would like to object to the notation "non-serious publication". Unfortunately, some of the referee's comments are extremely difficult to answer since several misinterpretations occurred. In case of some of his criticism we have the impression that he overlooked important experimental details (especially see the darkening experiment, point 13) or ignores common ways of data evaluation and calculation (see determination of the standard emission factor, point 11).

We would like to call the attention to the fact, that most of the previous investigations on beech trees were made on few branches and leaves grown in potted plants. These data are presently used for calculating emission inventories. Our actual data belong to the few obtained in the field, within a season, when the highest emission was reached. The fact that the emission of Fagus sylvatica has been found to reach much higher levels in the field than observed in some previous studies carried out at leaf and branch level will provide important information. It may for instance indicate that strong seasonal variations in the basal emissions take place as also observed for Quercus ilex (Ciccioli et al. 2003). We are convinced that such field data are crucial to model beech emission for emission inventories. Does the referee really believe that the use of few existing data obtained under laboratory conditions will provide a better emission inventory than that based on few but reliable field data?

In contrast to the remarks of the referee, we stated that our measurements comprise a huge set of data, including the monitoring of micrometeorological and physiological parameters over a total of 24 days to grant gentle conditions for the plant and to interpret the measured monoterpene emissions. Furthermore, no visible effects of stress introduced by the enclosure system to the measurement plant were observed. We are sure, that our data are valid and we are glad that this manuscript has been published in Biogeosciences Discussions.

1. Absence of line numbering:

First of all, we would like to excuse that the numbering of lines and pages was not available for the referee and we appreciate the referee's time consuming work to comment the manuscript. We nevertheless assume that this should not have caused any misinterpretation. The manuscript file that was submitted to the production office contained no line numbering according to the example document published by Biogeosciences (see http://www.copernicus.org/EGU/bg/WORD_submit.html). It may be helpful for the referee, to use the published BGD version instead. There lines are available.

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2. Assumed change of the sampling methodology:

The sampling methodology was never changed within the course of the experiments. Obviously the referee misunderstood this detail. Samples were collected with the same automated cartridge samplers during the experiments of 2002 and 2003 simultaneously from the reference cuvette, the sample cuvette as well as from ambient air. These samples were analysed by GC-FID. Additional samples were collected occasionally in 2002 (data not shown in the manuscript) and 2003 (again from the reference cuvette, branch cuvette and from ambient air) and were analysed by GC-MS.

3. Evaluation of potential effects on the microclimate inside of the enclosure:

As outlined in our former reply to the comments of the referees # 1 and 3, temperatures were measured by application of several ultra fine Teflon covered thermocouples (0.005 inch, Chromel-Constantan, [Omega, UK]) outside but next to the sample cuvette, in the reference cuvette, as well as in the sample cuvette. Leaf temperatures were measured by application of the same type of thermocouples simultaneously on the upper- and lower sides of 2 representative leaves inside of the branch enclosure. Leaf temperatures reported in the manuscript represent the average of these four leaf temperature measurements. Temperature differences between the branch enclosure and ambient temperatures (measured next to the enclosure) ranged $<2^{\circ}$C and $<1^{\circ}$C for the major part of the day in 2002 and 2003, respectively. However, at some days (especially in the year of 2002) midday and afternoon differences of up to 7°C and 4°C could be observed. Regarding the highest leaf temperature (not the air temperature!) measured in our experiments (44°C, in 2002), the difference between the branch enclosure temperature (40°C) and ambient temperatures (36°C) varied by 4°C. We agree with the referee # 3 that the variations between ambient climate and enclosure temperatures should be carefully discussed. We will further improve the information considering the variations between ambient and cuvette temperature in a revised version of the manuscript.

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4. Representativeness of the measured branch:

As outlined in our former reply to the comments of the referees # 1 and 3, measurements performed on European beech during the present study are in good agreement (both in light dependence and/or measured standard emission factor) to the laboratory and field experiments conducted by several authors (Kahl et al. 1999; Schuh et al. 1997; Spirig et al. 2004; Spirig et al. 2005). The selected branch was chosen for our measurements, since it was sunlit, accessible from the measurement tower, straight grown, and contained (in relation to other branches) a minimum of partially shaded leaves. The microscopic analysis of representative leaves proved these leaves to be sunlit and improved confidence. This was not useless. As outlined by the referee, the specific leaf area could be more meaningful than the microscopic analysis. Here, we fully agree with the referee. Therefore, we performed such measurements and presented the specific leaf areas in Table 1. They ranged from 108 g m-2 (2002) to 77 g m-2 (2003). We measured also shaded leaves of the same tree and found a significant lower value of 36 g m-2 in 2003. The latter data were not mentioned in the manuscript, but we will include this information in a revised version of the manuscript. However, other parameters like variations in d13C or the content of nitrogen and or starch were not measured. Moreover, canopy leaf temperatures were not recorded and we are not able to prove that our measured leaf temperatures reflected this system indeed. We intend to include such an approach for next field experiments.

5. Headline of the experimental part of the manuscript:

We preferred to use the term “experimental” rather than “methods” since the relevant paragraph gives an overview of the field site, describes the experimental setup and analytical systems, as well as the model calculations that were applied.

6. Zero tests of the cuvette system and assumed shifts in airflow:

In contrast to the remarks of the referee, we would like to state, that we have characterised our system under field conditions in detail since more than a decade now.

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The air flow to each of the both enclosures was adjusted (25-35 l min-1 per cuvette, difference typically <2% in 2003, <9% 2002) to grant a sufficient exchange of the cuvette volume every 2-3 minutes. The flow was monitored for each cuvette. Tests of our empty cuvettes were always performed by default (!) for differences in monoterpene, CO2 and H2O concentrations. This is a common part of all our cuvette measurements. CO2 concentration differences of the empty system ranged <2% (2002) and <5% (2003) of daytime CO2 concentration differences. H2O concentration differences of the empty system ranged <10% and <2% accordingly. Monoterpene differences ranged at 0.0 +/- 0.5 ppb and 0.0 +/- 0.1 ppb in 2002 and 2003, respectively. The latter difference ranged <1% of the daytime monoterpene emission measured from Fagus sylvatica in both years.

7. Citation of the submitted manuscript Kuhn et al. (2005):

We agree with the referee, that referring to a yet unpublished (submitted) paper for a detailed description of the automatic cartridge sampler can be criticised. However, since the VOC sampler was already described in several of our recent other publications that are already cited within the manuscript, we will also refer to these papers.

8. Decomposition of sabinene on GC-MS adsorbent traps:

In a laboratory study sabinene was shown to be decomposed on the GC-MS adsorbent tubes. However, as outlined in our former reply to the comments of the referees # 1 and 3 the main conclusion of this paragraph, that sabinene was the major compound emitted by European beech, remains unaffected by this effect, since sabinene represented the main component on these adsorbent traps, even if no correction factors were applied. Moreover, these results are in good agreement to recent other publications (e.g. Schuh et al. 1997).

9. Assumed extrapolation of data obtained by GC-MS analysis:

Sabinene was shown to be decomposed on the GC-MS adsorbent tubes. Standard

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emission factors derived from these measurements in 2003 differed by a factor of 1.3 from the average standard emission factor derived from GC-FID analysis for the respective year. Although the difference between the GC-MS and GC-FID analysis is small, we are in accordance with the referee that use of these data for extrapolation to European scale is critical. Therefore, the standard emission factors derived from the GC-MS analysis were not used for the extrapolation of our data to European scale. Extrapolations were obtained by utilisation of the average standard emission factor derived from GC-FID analysis in 2002.

10. Saturation and optimum curve shown in Figure 3:

The saturation and optimum curves shown in Figure 3 do not represent a fitted curve to our data but the respective light and temperature function of the G97 algorithm (adjusted to our SEF). This was indicated in the figure legend. Obviously the referee misunderstood this detail. We regarded the curve as a help for the reader to discuss our data set. To prevent misinterpretations of the respective diagram we will additionally indicate this at both curves in the diagrams as well.

11. Calculation of the standard emission factor:

The standard emission factor given for monoterpene emission from Fagus sylvatica represents the slope of the linear regression of the sum of monoterpenes versus the product of the respective light (CL) and temperature (CT) function (Guenther et al. (1993; 1995; 1997) and Schuh et al. (1997)). This procedure is common for the calculation of standard emission factors under natural conditions in the field (see e.g. Kuhn et al. 2002; 2004). We will include more information in a revised version of the manuscript and will define the terms CL and CT in more detail in the Appendix A.

12. Absence of night time monoterpene emission:

Monoterpene emission in the absence of light was not detectable in the present study. Other authors observed small emissions of monoterpenes from other plants under

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night time conditions and related these emissions to the presence of monoterpene storage pools within the leaves (Loreto et al. 1996; Niinemets and Reichstein 2003; Niinemets et al. 2004). Accordingly, we discussed the relevance of these storage pools for our measured tree species. We will change the term “storage pool” to “monoterpene storage pool” in a revised version of the manuscript to prevent misinterpretations. However, it remains unclear to us, how the carbon status of the leaves would help to discuss these data, since such monoterpene storage pools inside these deciduous leaves are thought to be very small (in relation to the total carbon content of a leaf). We do not think that we would have been able to detect such small differences. Therefore, the carbon status was not measured in the present study. We will shortly discuss this in a revised version of the manuscript.

13. Artificial darkening experiment:

We agree with the referee that 30 min of a shading experiment would not have been a sufficient time scale to prove the light dependency of European beech. Obviously, the referee misunderstood the technical details. The artificial shading of the plant was performed for ˜2 h during daytime (see Figure 5 and the respective paragraph). As reported in the text the total time to cover the enclosure system took 30 min, since the enclosure was not easily accessible. Subsequent 2 h of artificial shading were performed. Within this time three samples as indicated within figure 5 were taken. Sampling lasted 30 min per sample as described within the "Experimental" chapter. After this period the artificial cover was removed again. Increasing temperatures had no effect on monoterpene emission and therefore clearly proved the demand of monoterpene emission for light. We will discard the sentence “the artificial darkening...was completed within 30 min” in a revised version of the manuscript since it may lead to misunderstandings. However, we will not omit this experiment, since it is one of the key results to support the light dependence of monoterpenes.

14. Utilisation of the term “standard emission factor”:

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As described above, cuvette temperatures were not run at unrealistic conditions. The term “standard emission factor” refers to an actual temperature of 30°C and an actual radiation intensity of 1000 μmol m-2 s-1. Measurements performed under natural conditions comprised a wide range of temperatures and radiation intensities and were not limited to these standard conditions. In accordance with the VOC community, standard emission factors were calculated from the slope of linear correlation of monoterpene emission to the light and temperature function of the G97 algorithm (Guenther et al. 1993; Guenther et al. 1995; Guenther 1997). Since this algorithm takes only the actual temperatures and radiation intensities into account, previous environmental and physiological conditions (temperature history or developmental status of the plant) are neglected. We will address this issue in a revised version of the manuscript. Since monoterpene emission is a function of light and temperature, comparison to the data obtained by other studies applying different environmental conditions is only possible by calculation of this standard emission factor. Since our standard refers to this well accepted G97 algorithm the term standard emission factor is justified.

15. Midday depression of photosynthesis:

As outlined in our former reply to the comments of the referees # 1 and 3 a reversible midday depression was observed on several days during both field experiments. The daily correlation of photosynthesis and stomatal conductance to PAR (presented in Figure 7) shows a hysteresis structure typical for midday depression which is in accordance with Tuzet at al. (2003). For a better understanding, it should be mentioned in the figure legend and in the relevant chapter that the daily maximum values shown here were derived during the morning hours, while lower values were measured during the afternoon. We will include some comments on this in a revised version of the manuscript.

16. Extrapolation to European scale:

Measurements performed during the present study are in good agreement with pre-

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vious studies. Standard emission factors measured within the present campaigns covered a range of 4 to 13 μg g-1 h-1 and proved the light dependency of monoterpene emission. Monoterpene emission factors that were assigned to temperate forest ecosystems (Guenther et al. 1995; Olson 1992) account to 0.9 μg g-1 h-1 only. Regarding the measured monoterpene emission factors for Fagus sylvatica (4 μg g-1 h-1 in 2003 or 13 μg g-1 h-1 in 2002) we do regard an increase of a factor of 4 to 14 induced by a single tree species of this ecosystem type as highly important. It leads to a substantial increase of the emission, whereas the observed light dependence of monoterpene emission will cause a decrease of the estimates again due to the restriction to day light. This was demonstrated within a complex model.

17. Size of paragraphs:

Since the referee was concerned about the size of paragraphs and the missing interrupts presented in the manuscript, we will insert the relevant interrupts in a revised version of the manuscript.

18. Contents of the abstract:

Since the referee was concerned that the abstract of the manuscript contained too many qualitative data, we will include the numbers of measured standard emission factors of Fagus sylvatica. Moreover, we will quantify the increase in the European VOC budget in the abstract in a revised version of the manuscript.

19. Contents of the introduction and hypothesis:

The referee was concerned of overstatements included in the introduction as well as its general form. Unfortunately the referee did not specify his criticism. We are not able to comment this point, since we do not understand the referee's intentions. Moreover, we mentioned the joint field experiment within ECHO. That is not only good use but needed to discuss our contribution to the whole outcome of the experiment. Furthermore, within the next sentences the goals of the work are sufficiently described.

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